Inner Northern Busway:
Queen Street to Upper Roma Street

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ABSTRACT

The Inner Northern Busway – Queen Street to Upper Roma Street (INB) project completed the central link in Brisbane's world class busway network. It connects the northern, south-eastern, eastern and future western bus transit routes, and greatly improves urban connectivity and travel times while removing buses from busy city streets. Design and construction of the project was extremely challenging. The 1.2km project was very complex; with no single 50m section the same. The project included a 500m tunnel, two major bus stations within existing city structures, a Cycle Centre and significant road and rail interfaces. The INB project was delivered under budget and six months ahead of schedule over a three year period. The project also set new benchmarks for sustainable design and construction; exceptional quality, innovation and team management; and effective community and stakeholder relations. This paper, based on the ACAA award nomination prepared by the INB HUB Alliance partners, focuses on technical and management innovation as evidenced in the INB project. In particular, the paper details six of the most complex and difficult design and construction challenges faced on the project, and details how project leadership and management innovation helped to deliver outstanding project outcomes.

KEY WORDS

Alliance, Brisbane City Council, Bligh Voller Nield, busway, Coffey, community, contract, Countess Street, EDAW, Fire Life Safety, INB HUB Alliance, Inner Northern Busway, innovation, key result areas (KRAs), Queensland Transport, Leighton Contractors, management, Maunsell AECOM, performance, public transport, schedule, stakeholders, structural, technical, transport, tunnel, ventilation

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INTRODUCTION

The Queensland government is creating a world-class busway network that will eventually span Brisbane, Australia's fastest growing city. Busways provide city commuters with significant travel time savings, reduced traffic, improved air quality and noise levels and greater urban amenity.

The Inner Northern Busway (Queen Street to Upper Roma Street) project completes the 'missing link', connecting Brisbane's CBD to the rest of the Inner Northern Busway. As a central link in the Busway network, the Inner Northern Busway connects the northern, south-eastern, eastern and future western bus transit routes.

The new busway connects with and expands on existing cycling and pedestrian infrastructure and underpins new 'walkable' urban developments. It is the first project in Brisbane to fully integrate transport services by placing a cycle centre (end of trip facility) within a busway station and a busway station within a rail station, integrating with intra and interstate trains and buses.

The project was a significant design and construction challenge. The challenges of building a major piece of civil infrastructure, integrated with existing buildings and major transport infrastructure, through the heart of Brisbane's CBD was made even more difficult through:

- complex inner city/CBD environment with major utilities (electricity, gas, water, sewer and telecommunications)
- construction through existing buildings while maintaining full operation, including nine-level underground public car park beneath King George Square (KGS) and the rear of Brisbane Transit Centre
- construction across and under major city streets while maintaining traffic flow
- heavy excavation and construction near City Hall, an historic church and a four–star hotel
- remodeling rail tracks, bridges and heritage-listed platforms at Queensland's main passenger rail hub
- working with 1000+ stakeholders impacted by the project
- supporting inner-city business activity during construction, and
- managing major scope changes.

SCOPE OF WORKS

The original project scope was based on a much smaller scheme of INB1 (between Queen Street and Roma Street). Queensland Transport's Request for Proposals outlined 15 functional requirements including:

- tunnel under Albert Street connecting Queen Street Bus Station to King George Square (KGS) car park
- underground busway station through KGS car park with two 55m long in-line platforms, and
- bus turnaround at one end of the KGS Busway Station.

There was no agreed concept for the busway to link from the new KGS Busway Station to the existing busway at Countess Street. The original scheme travelled up Roma Street with a poor connection to Roma Street Railway Station and potential bottlenecks for local traffic.

Following appointment of the INB HUB Alliance in May 2005, preliminary design and budget development proceeded. The project scope was consequently expanded to include INB2 (Roma Street to Countess Street). The alignment for this section was agreed as a dedicated off-street busway proceeding through the Roma Street Forum, behind the Brisbane Transit Centre (in railway land) and connecting to the constructed part on INB. A western connection was also included, over Countess Street and connecting with Upper Roma Street adjacent to the fire station.

The scope of works ultimately included:

- world class busway
- busway station in the lower levels of KGS car park (with the car park to remain operational throughout construction) with two 130m long platforms providing five inbound and five outbound stops and platform concourses
- busway station at the Brisbane Transit Centre integrating with intra and interstate trains and buses
- 500m long tunnel joining to the existing Queen Street Bus Station (QSBS) and tunnel
- two underground bus turnarounds
- major alterations to the Roma Street Railway Station without impacting on rail services (remodelling of two rail platforms, one rail track removed and two rail tracks re-laid in a new dual gauge configuration), and
- major public utility provider and traffic interface work to enable crossings across major CBD streets such as Ann Street, Turbot Street and Adelaide Streets.

Additionally, five projects were added to the agreed scope of works, namely:

- early delivery of the Caxton-Roma Pedestrian Link – a pedestrian bridge forming part of the government's ongoing Suncorp Stadium development
- early delivery of a section of KGS surface works, initially designated as future Brisbane City Council (BCC) works
- inclusion of a purpose-built Cycle Centre within the KGS Busway Station envelope
- provision of a Transport Information Centre for BCC and the Queensland government, and
- laying 500m of a pipe under the foundations of the busway for Brisbane's future recycled water network.

Figure 1 below outlines the INB design and key construction features and illustrates the key design and construction features against a long section of the project.

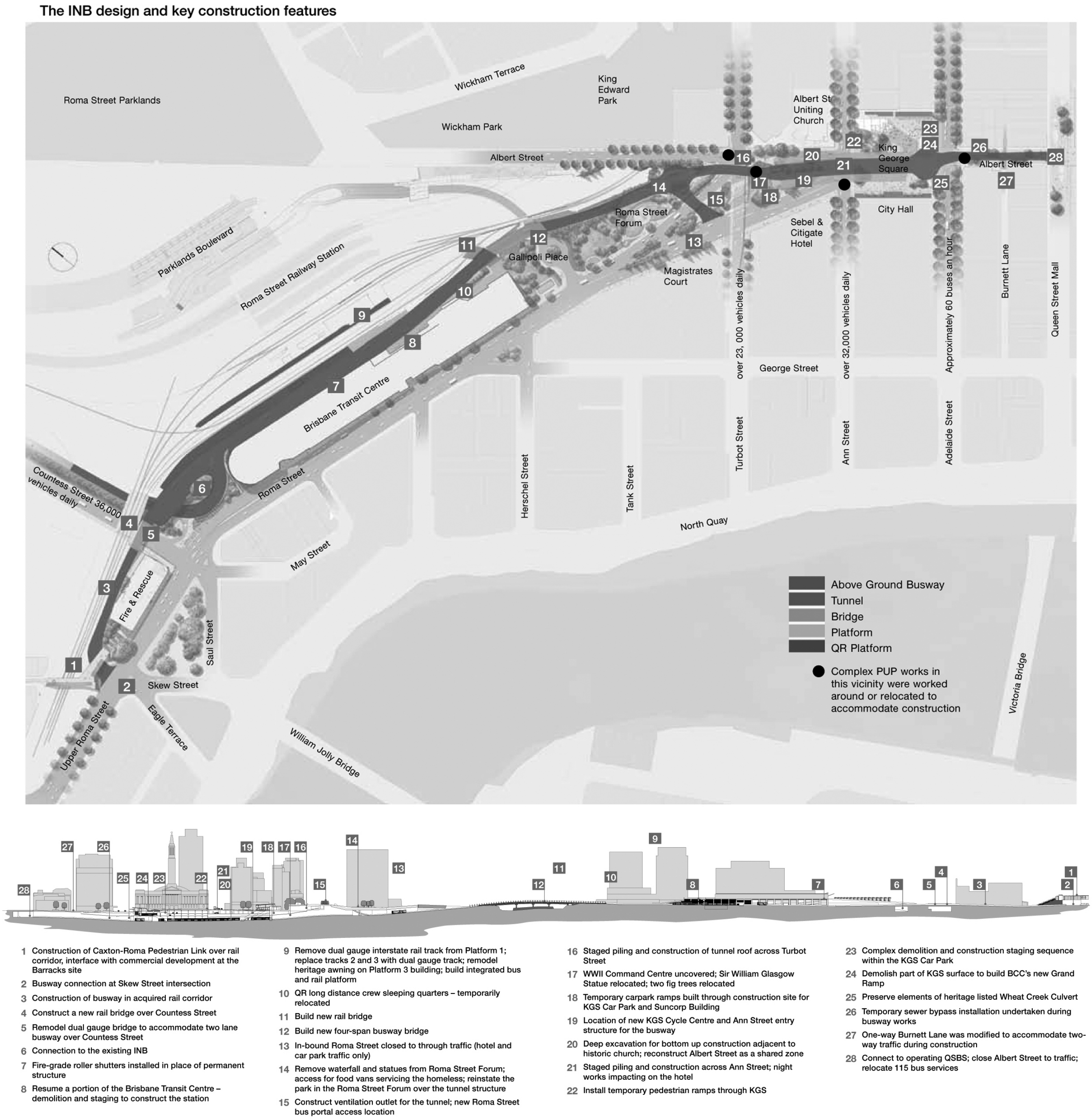

Figure 1: INB design and key construction features

TYPE OF CONTRACT

This Alliance was different from many other Alliances, where the basic scope of the project is known and approved when the Alliance is formed. In this case, the project parameters were extremely broad and the new team developed an agreed project scope (the Reference Scheme) in consultation with key stakeholders. The Alliance partners were Queensland Transport (client), and non-owner Alliance partners Leighton Contractors, Maunsell AECOM (now AECOM), Coffey, Bligh Voller Nield and EDAW (now EDAW AECOM). The Alliance model was identified as the best approach to deliver the project within a very tight budget, while providing the bus operational flexibility and greatest confidence of best value for QT and other stakeholders. There was a strong expectation that an Alliance would achieve the kind of breakthroughs that were needed to meet or exceed project objectives – breakthroughs that would not have been possible using other methods.

Under the Alliance agreement proposed by QT, all participants took collective ownership of all risks associated with project delivery, with equitable sharing in agreed ratios of ‘pain’ or ‘gain’, depending on how outcomes compared with pre-agreed targets. The client and a large multi-disciplinary team worked together in a relationship based environment to successfully deliver very challenging goals through high performance, innovation, open communication and a no-blame culture. A critical client expectation was that the team would construct the busway with minimum impact on neighbouring stakeholders and the city’s travelling commuters – and this key goal was achieved.

Further information on alliance contracting can be found in the following publications:

Morwood, R; Pitcher, I; & Scott D, 2008 *Alliancing: A participant’s guide: real life experiences for constructors, designers, facilitators and clients,* Rohan Exton, Australia.

Department of Treasury & Finance (Victoria), April 2006, *Project Alliancing Practitioners’ Guide*, Department of Treasury and Finance, Victoria.

TECHNICAL CHALLENGES AND INNOVATION

This section focuses on six of the most complex and difficult design and construction challenges faced and overcome through ingenuity and innovation.

1. STIFFENING WALL – KING GEORGE SQUARE CAR PARK

The spatial envelope for the busway within King George Square (KGS) car park required extensive demolition and modification of numerous horizontal and vertical structural elements. The twin bus carriageways required the removal of the lower two levels of floor slabs, and the relocation of all three grids of supporting columns, to suit the new bus lanes and station platform layouts. The space required for the concourse directly above the busway required the removal of the upper two levels, including the roof structure. In total, four of the five levels of horizontal slabs were removed, which necessitated an innovative and highly engineered demolition sequence, to maintain structural stability during construction.

Typical of most underground structures, the external walls relied on the floor slabs to resist earth pressures acting inwards. Before demolition of the four levels of floor slab, the southern external wall (adjacent to City Hall) had to be stiffened first. This was needed for the final wall configuration, where intermediate slab levels were removed and the wall structure spanned vertically between the new roof, concourse and busway levels. In the concourse area, the stiffening works extended for the full height of the underground structure, from the busway slab up to roof level. The stiffening was necessary to control wall deflections and prevent subsequent foundation settlement of the City Hall on the other side.

The complex stiffening works comprised of a reinforced concrete inner wall, minimum 500mm thick, placed on the inside face of the existing wall. The stiffening works had to be installed while the floor slabs were still in place, maintaining horizontal propping to the external wall. Continuity of the vertical stiffening wall through floor slabs was achieved by a “hit-and-miss” approach, where 1200mm x 500mm slab penetrations were cut parallel to the existing wall, with an undisturbed 300mm wide strip of floor slab between each penetration. The 300mm wide slab strips provided horizontal propping to the existing wall while a temporary steel jack was placed transversely inside each penetration, lying horizontally.

Once the steel jacks were in place and tightened, the 300mm wide concrete strips were saw cut and removed, leaving a 7200mm long x 500mm wide slot with five horizontal steel jacks, regularly spaced, across the slot. This occurred between each column grid, spaced at 8000mm centres, providing 90% structural continuity along the length of the existing wall. This process was repeated on multiple levels, with each floor slab propped vertically to account for the lost support at the disconnected wall/slab joint.

Before wall steel reinforcements were placed, the steel jacks were blocked out with polystyrene. The steel reinforcement was placed through the slot in the floor slab, around the steel jacks. Reinforcement bars directly under the steel jacks were fitted with threaded couplers and placed hard up against the underside of the polystyrene block-outs. Wall concrete was poured one floor level at a time, up to the top surface of each floor slab.

Once the new concrete had gained adequate strength, the new wall concrete inside the slab penetration re-established a load path for the horizontal propping loads between existing wall and floor slab. The polystyrene block-outs were broken out, and the steel jacks removed. This enabled the location of the threaded couplers under each polystyrene block-out, into which reinforcement bars were screwed, ready for the next lift of stiffening wall.

This innovative construction method provided more station platform width by utilising an efficient wall system of minimum thickness. This made possible the enhanced arrangement of lift, stair and escalator being located side-by-side, adjacent to the busway. It also enabled the demolition of four of the five slab levels of the underground structure, whilst maintaining structural stability of the fully operational car park.

2. TRANSFER BEAMS KING GEORGE SQUARE CAR PARK

The combination of restricted vertical clearance and a need for column-free space were the primary drivers for a complex arrangement of high-level, concourse-level and below-concourse-level transfer beams. In most cases, the transfer beams were required to pick up the loads from existing columns on the car park grid and transfer them down to ground via a new column arrangement, according to the busway layout.

High level transfer beams

These beams are located within the new roof structure, and also form part of the aesthetic of the concourse ceiling. For ease of construction, these 2000mm deep x 1050mm wide beams used the level B floor slab as a working platform, prior to level B slab demolition. [Note: KGS car park is a nine-level basement car park with two halves offset by one level. Hence, the northern half comprises A (adjacent to Adelaide Street), C, E, G and I levels, and the southern half comprises B, D, F and H levels. Busway construction removed most of the southern half of the car park].

At numerous locations, these beams are the supports for “hanging columns”, where existing columns down to the concourse slab are supplemented by 4x50mm diameter tension bars acting as suspension rods to the concourse slab below. The intention was to vertically support the existing slab below in the same locations as the original car park structural layout, but without continuing the column down below concourse level. This enabled the existing concourse level slab to be retained as a critical horizontal propping element, and to provide a column free space below in the busway station. The high-level transfer beams act as multi-functional structural elements as follows:

- Roof support
- Horizontal restraint for the waler beam on top of the stiffening wall

- Horizontal strut between stiffening wall waler beam and existing shear wall, and
- Adelaide Street tunnel roof support beam at grid B (acting like a bridge structure).

Figure 2 below from the "Area 10 Construction methodology" shows the transfer beams (viewed from the South East in Adelaide St). The shorter beams are on level D, the longer beams are on level B of the car park. The beams are located on each grid line of the car park.

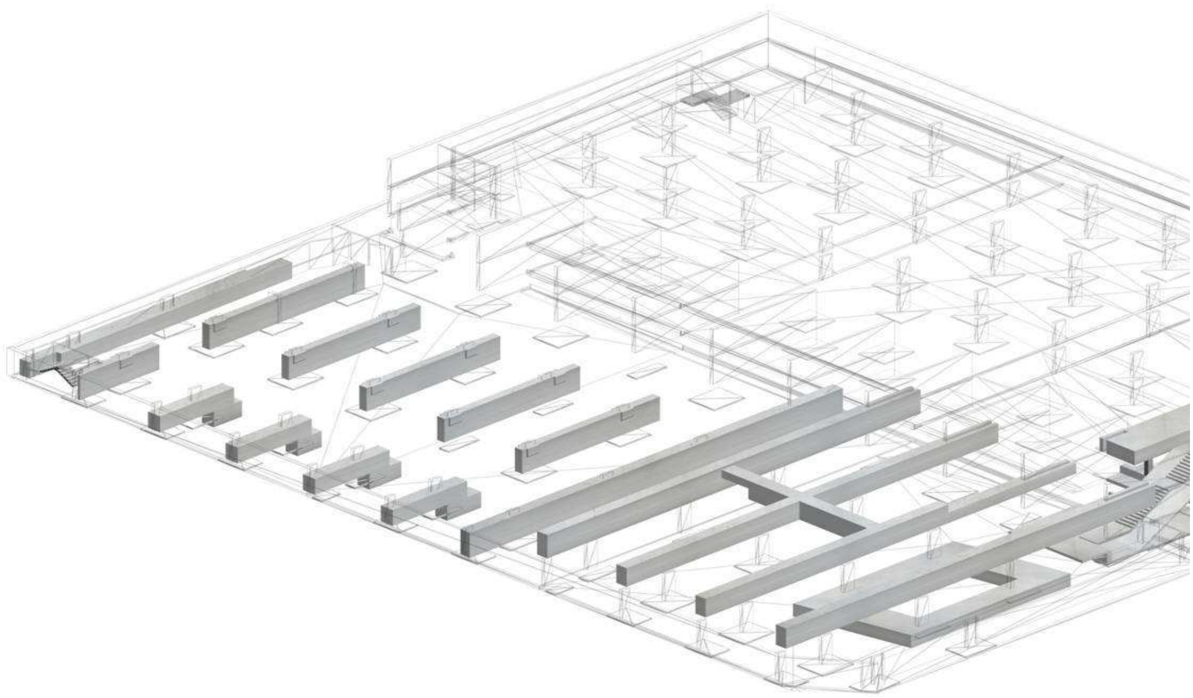

Figure 2: Transfer beams viewed from the south-east in Adelaide Street

Concourse level transfer beams

These beams are located on top of the existing level D slab, within the operational car park, and are generally full depth (slab to slab) to maximise structural capacity with minimum width. The use of top-of-slab beams achieved maximum vertical clearance for buses below, while being configured in a way so as not to impede car park operations. The method of load transfer between existing columns to beam was via an embedded, heavily doweled connection. This connection comprised 4x40mm dowels passing through each existing concrete blade column with a large bearing plate on each end of dowels, embedded in the body of the transfer beam. The intention was to mobilise friction shear forces by clamping the new concrete to old via the dowels and bearing plates. The construction method was a significant departure from the norm and was difficult to construct, but it allowed an optimum busway alignment to be achieved below. Generally the reinforcement was detailed for strut-tie action, and typically adopted N40 reinforcement bars to resist tension forces. The innovative design allowed the car park to remain fully functional, despite the significant structural modifications in the area.

Below-concourse transfer beams

Limited vertical clearance in the busway only allowed these beams to be located over the round-about or over the platforms, the most significant being over the roundabout, being 3000mm wide and 1300mm deep. This beam allowed the transfer of a regular grid of car park columns to be picked up on an irregular grid of columns in the traffic islands of the round-about below. It also kept clear of the smoke duct structure (refer to section 3 Fire Life Safety System) which required a significant amount of space over the busway.

The beam perimeter was required to be built in stages due to the large cut-outs for its installation in the level D concourse slab. The cut-outs for the full beam perimeter would have compromised the load path of horizontal propping forces in the slab, and therefore the beam was installed in three stages, with progressive slab removal. Critical consideration was given to the timing and sequencing of excavation activities in Adelaide St tunnel when this beam construction was taking place. Threaded couplers were used to splice the steel reinforcement. The beam used a similar heavy dowelled connection to transfer the existing column loads into the new beam/columns.

3. FIRE LIFE SAFETY SYSTEMS

The Fire Life Safety Systems in the INB are the subject of a separate technical paper (Matthew Bilson, Peter Gehrke, Andrew Purchase and Dr Conrad Stacey – see references for further information. This paper will be presented at the 13th International Symposium on Aerodynamics and Ventilation of Vehicle Tunnels on 13-15 May 2009). The text in this section has been condensed or directly reproduced from that technical material, appropriate to the current focus.

In designing, constructing and commissioning the Fire Life Safety (FLS) systems, numerous ventilation design challenges were faced for normal (pollution) and emergency (smoke) ventilation. The final design solution was an integrated system that accommodates pollution removal from the bus tunnel and smoke exhaust for the bus tunnel and building spaces. It needs to cater for varying normal operating modes and facilitate safe occupant egress and fire brigade access during a fire. The numerous technical challenges included:

- **Limited site and space provisions** for ducting or ventilation plant.
- **Surface amenity:** Ventilation exhaust and supply points were limited and egress provisions impacted by existing structures. Fire-isolated exits to the surface were not possible.
- **Operations:** Connecting to existing Queen Street Bus Station (QSBS) meant integration of normal and emergency operations in the two stations, during construction and after opening.
- **Pollution separation of platforms:** The platforms and busway are separated by glazed panels and doors. A balance is required between pollution ingress to the platform and loss of conditioned air to the busway.
- **Building and tunnel interface:** The platforms and concourses are covered by the Building Code of Australia (BCA) which is not applicable to the tunnels. At the tunnel-platform interface, accommodating the BCA provisions presents challenges with fire separation and smoke management.

The features provided to meet the ventilation goals and design challenges included:

- An extensive duct system for removing pollution under normal operations and smoke in the event of a fire. The integrated system serves both the tunnel and building spaces (platforms and concourse).
- Jet fans for control/balance of normal operations airflows and smoke control/removal.
- Zoned smoke exhaust to minimize smoke spread and maximize safety. The exhaust system has automatic process controls and a full time operator.
- Fire services features integrated with the smoke management system, including: a customized wall wetting sprinkler system on glazed panels; linear heat detection in tunnel; pressurized egress passages; deluge system for bus station and bus stops; and concourse smoke curtains where permanent ceiling smoke barriers were not architecturally desirable.

Ventilation duct design

The INB facility incorporates a large duct network for normal and emergency ventilation. Dual duty fans are located at the Roma Street end. Three axial fans of 2 metres diameter are installed. Determination of multiple fan duty points for the complicated duct system required the use of computational fluid dynamics (CFD). CFD was used as the geometry was highly three-dimensional (see Figure 3). The ventilation duct geometry was constrained by the tunnel alignment, existing services (e.g. sewer mains) and structural/architectural requirements. This led to a complicated geometry requiring significant coordination between disciplines and continual re-analysis as design progressed. The duct is supported by a suspended steel frame and hangers, further complicating the analysis.

The CFD geometry was based on engineering drawings and sketches. Over 70 CFD models were run for various modes of operation and covering all stages of the structural design. The commissioning measurements verified the veracity of the CFD modelling undertaken.

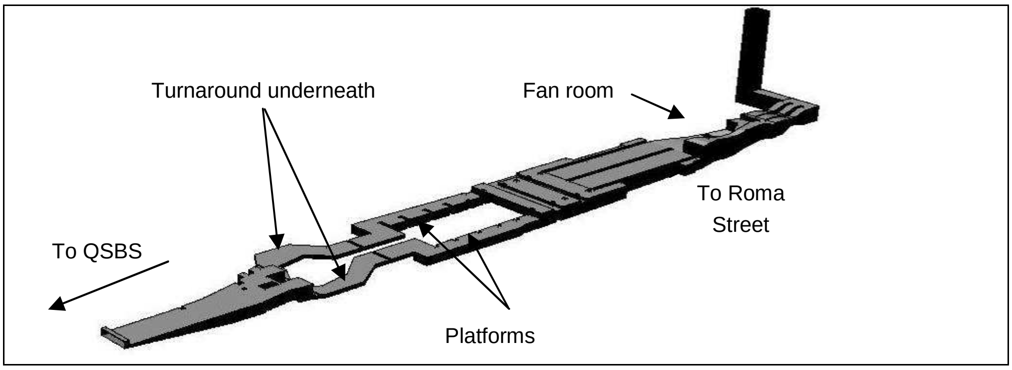

Figure 3: CFD geometry for the ventilation duct design (damper locations not shown)

Tunnel ventilation – Normal operations

The design for normal operations ventilation needed to achieve a number of goals including pollution, temperature and velocity control. Achieving these goals was difficult given the nature of the facility:

- Bus traffic was bi-directional with AM and PM peaks. Bus timetables are subject to change.
- There was no room to incorporate an air supply system which meant the system was limited to exhaust only. Connecting tunnels had limited headroom and width, meaning that locations for jet fans were not optimal. Uni-directional fans had to be incorporated into the design.
- The design had to be integrated with smoke management systems, requiring constant coordination between operational and FLS goals.
- There was a notional requirement for no emissions from portals, meaning that pollution could not simply be blown through the tunnels.
- The interface with platforms: The goal was to prevent busway emissions entering the platform area through open platform screen doors. Platforms are air-conditioned, so too much air drawn from the platforms would reduce the air-conditioning effectiveness, and too little flow would mean that buses would push tunnel air into the platforms.
- The interface with existing QSBS: The new system had to operate without compromising operations in the QSBS, and the new system had to accommodate changing ventilation operations in QSBS.
- Aerodynamically, moving buses would have a significant dynamic effect on tunnel airflows. This created challenge to the aim of minimising operational complexity (i.e. set and forget).

Static and dynamic emissions calculations were undertaken accounting for the fleet characteristics and transient behaviour of the facility. Tunnel environment simulations were also undertaken using SES and verified with steady-state CFD and commissioning measurements.

This analysis allowed the normal operations ventilation capacity to be estimated for fan sizing. To minimise power consumption, the normal operations ventilation is controlled by sensors that monitor acceptable pollution levels. The required ventilation flowrate is then controlled by VSDs.

Tunnel ventilation – Smoke management

The system is designed to accommodate a fire load corresponding to one or two buses at peak heat release (30 – 50 MW). The smoke exhaust system is zoned to minimise smoke spread and maximise occupant egress time. The exhaust system (dampers, fans) has automatic process controls for operational simplicity. The operator does not control individual items of equipment but instead nominates the location of the fire. Redundant options for each fire location are available and additional responses are also available for fire fighting.

Extensive CFD modelling was used to develop the smoke management design, inform the structural and architectural designs, and obtain stakeholder agreement. Over 500 CFD models were run through the life of the project covering numerous scenarios and sensitivity cases. Commissioning measurements confirmed the success of the modelling undertaken by measuring cold airflows and undertaking hot smoke tests.

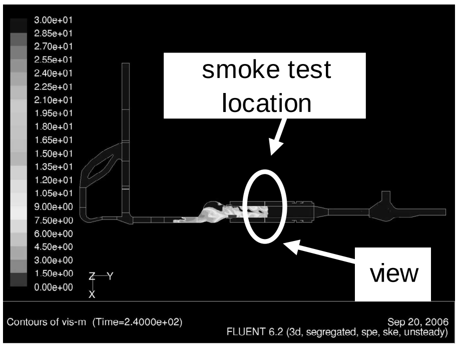

Figure 4: Hot smoke test image compared to CFD result of smoke spread

Building smoke management

Under the BCA, the platforms and concourses are classified as a Class 9b (public assembly) building. Due to the size of the facility and the number of storeys (three or more), a smoke management system was required by the BCA. For each main building area the following smoke management system was implemented:

- **Platforms:** The ventilation duct runs directly above the platforms and dampers were installed in the ceiling of the platform. For a fire in this area the dampers are opened and smoke is contained due to the very high exhaust rates.
- **Ann Street concourse:** This area is at grade and has a mostly open ceiling. Natural ventilation, combined with a low rate of pressurization from the platforms below was used. Pressurisation is achieved by opening the platform dampers and operating the station fans in reverse at low speed.
- **Adelaide Street concourse:** The ventilation duct runs below part of the Adelaide Street concourse. A connection was made to the duct below to utilise the exhaust available.

Summary

The design and analysis of the FLS system for INB required an integrated approach to the tunnel/building ventilation design. Innovation was needed and CFD was an essential design tool.

4. WIDENING OF COUNTESS STREET BRIDGE

As a consequence of the decision to build the busway in railway reserve on the southern boundary of Roma Street Railway Station, the Alliance had to:

- relocate the dual gauge rail track from Platform One
- provide dual gauging of Tracks Two and Three and structural work on the platforms to allow for the re-routing of the larger XPT trains, and
- undertake approved modifications of the heritage listed building awnings on Platform Three.

To avoid traffic impacts from the closure of Countess Street, the Alliance made the decision not to build a new busway bridge over Countess Street by demolishing an existing rail bridge, but instead convert the existing narrow rail bridge into a two-lane busway bridge. The existing concrete rail bridge structure was, at the time, used by interstate XPT trains (as described above).

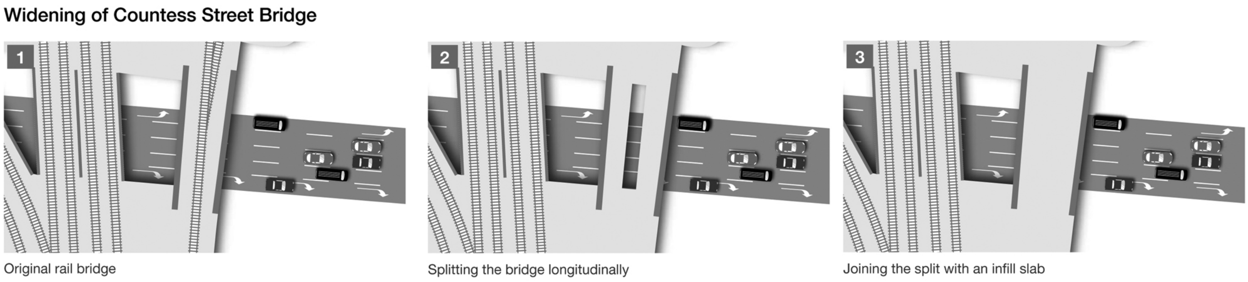

Figure 5: Three diagrams outlining the widening of the Countess Street Bridge

Retrofit works included jack-hammering and scabbling the existing bridge structure to expose reinforcement, and construction of new abutments and piles. The existing concrete bridge deck was cut longitudinally and then the southern edge beam and one half of the bridge deck, weighing more than 350 tonne, was raised off its headstock and shifted up to 4m to the south. Two low loaders and support frames were used with two 10 axle hydraulic trailers, each with a haulage capacity in excess of 250 tonne. The two bridge sections were then tied with a new structural slab, forming a wider bridge.

Reductions in waste from site through the reuse of the structure saved the project team from disposing of over 700 tonne of concrete, and there was a similar saving in replacement in concrete and reinforcing/pre-stressing steel for a new bridge.

The retrofitting and reuse of the existing rail bridge was a huge success for commuters because it minimised the number of road closures (and hence traffic disruption) on Countess Street.

5. ALIGNMENT AND GEOMETRIC COMPLEXITY

The area of the project between Ann Street and Turbot Streets was a very complex alignment and geometric challenge that required a coordinated and integrated design and construction response.

The works in this 100m section included:

- 2 lane busway extending under Ann Street and continuing behind Roma Street forum
- Roma Street busway station entry
- upper and lower plazas
- busway station concourse area
- two large smoke ducts (area totalling approximately 100m^2),
- Suncorp Building car park entry ramp
- KGS car park entry ramp
- large Cycle Centre and entry ramp
- reconfiguring street network, including Roma Street and Albert Street
- re-routing of major stormwater drainage
- minimising impacts on existing Turbot Street Bridge

- treatment of significant utilities
- plant and (jet) fan rooms, and
- urban design and landscape architecture features.

The complexity and degree of difficulty was heightened by the requirement to maintain temporary vehicle access to the operating car parks (i.e. KGS and Suncorp Building). There was also the need to maintain services in the adjacent road reserves and to maintain traffic movements in the busy city thoroughfares of Ann, Turbot and Roma Streets.

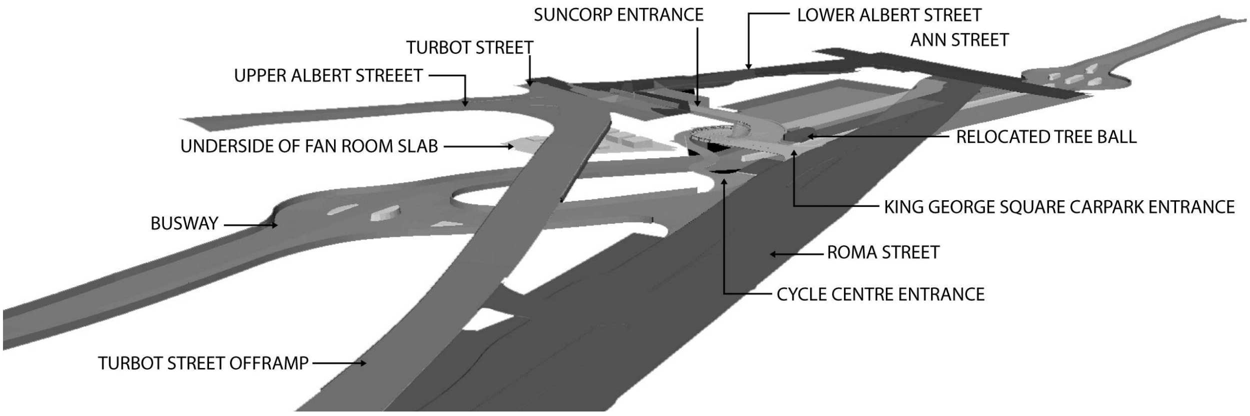

Figure 6: 3-Dimensional view of the Inner Northern Busway complexities

It was a unique 3 dimensional puzzle, created in concept design using *MX*™ and *AutoCAD*™ and detailed design completed using *12D*™. It required individual discipline based solutions (geometric design, structural engineering, civil engineering, mechanical and electrical services, architecture, urban design and landscape architecture) that worked together to provide a holistic solution. A collaborative approach was needed by all the individual discipline areas to ensure the solution as a whole worked. The Alliance structure allowed and facilitated this outcome which would have been extremely difficult to achieve through most conventional forms of contracting where different disciplines are separate consultancies/contractors.

6. USE AND DEVELOPMENT OF NEW TECHNOLOGIES

A number of new technologies were used on the INB, driven by the openness of the Alliance culture to new ideas and methods. The INB was one of the first projects to utilise sub-alliance agreements (discussed later in section: Project Leadership / Management Innovation of this paper) with key subcontractors. The willingness of the Alliance to spread the gain share/pain share approach with other parties assisted in achieving exceptional outcomes. Some of the new technologies incorporated with the use of sub-alliance agreements included:

- **Spinefex Lifeguard System**: A temporary power reticulation system which reduces the site establishment cost, provides a safer environment and simplifies changes as the site expands. The components are manufactured from high impact polyethylene which is resistant to corrosion and highly suitable for rugged construction site.
- **QMAP:** The project management system utilised innovative QMAP software which is a process mapping tool that is easy to use
- **Queensland first in concrete paving:** It was negotiated and agreed with Department of Main Roads (DMR) to amend their standard project specific Technical Specification for concrete pavements. The Alliance identified that the New South Wales Roads and Transport

Authority (RTA) had more experience with design, construction and maintenance of concrete pavements. The RTA Standard has been continuously improved to more accurately reflect "best practice". The Alliance utilised RTA's expertise in this area which allowed the DMR's Technical Specification to be challenged and amended appropriately.

- **Expansion joints removed**: The aim here was to improve the rideability of buses for patrons, reduce operational noise adjacent to a busy hotel and QR sleeping quarters for long distance train crews and reduce ongoing maintenance and operational costs. To achieve this, the team was able to construct 'seamless' structural pavement (without expansion joints) as busway bridge pavements while maintaining engineering standards.
- **Real time geotechnical sensors:** The Alliance used state of the art geotechnical monitoring activities to provide real time data on vibration and vertical and horizontal building movement.

PROJECT LEADERSHIP/MANAGEMENT INNOVATION

SHARED VISION

"Building a one team approach through strong leadership and a common purpose" was the shared vision prepared and signed upon by all parties of the INB HUB Alliance. The achievement of outstanding outcomes on the INB project is attributed to the calibre of leadership and management within the Alliance, especially of the Project Alliance Board (PAB) and Alliance Management Team (AMT). Leadership generated a shared vision and goals, while management delivered results through systems and controls. An Alliance principle was 'the right people for the right role' and this was followed by selecting the strongest candidates for all positions, enabling a 'do it right the first time' approach.

Leadership and management were demonstrated through the high level of innovation on the INB. All team members were committed to high performance, achieving outstanding project outcomes across all key result areas (KRAs), and behaving in accordance with Alliance principles at all times. Other Alliances such as Trackstar and CoalConnect have now adopted many of the leadership approaches used by the Alliance, most notably having People and Culture as a measured KRA and a Peak Performance Manager to drive outcomes. This approach is becoming an industry standard.

Because of its unique central Brisbane location, this high profile project was constantly under the spotlight during construction. It has impressed thousands with its approach and what it has delivered; and continues to do so daily with every Inner Northern Busway traveller. The Alliance has effectively shared their vision with Brisbane.

PROJECT DELIVERY

The AMT had an important control function but also empowered personnel to make decisions in their own fields. It included functional leaders to represent key disciplines of the wider project team. This included senior managers from the design, construction, commercial, safety, systems and controls, community and stakeholders, and peak performance teams, and was complemented by client and stakeholder representatives from QT, TransLink and BCC. This inclusion of senior client and stakeholder representatives optimised the decision-making process and ensured that the final selection of the preferred scheme was the best overall outcome for the project.

The innovative peak performance manager role was important in developing a high performing culture. This manager worked closely with the Alliance Manager and the AMT to develop a Peak Performance Plan (an Alliance first) to link the day-to-day activities of the Alliance to the project's vision, goals and objectives. This role was integral to the development of a powerful culture, the adoption of associated Alliance behaviours and achievement of the People and Culture KRA.

Leadership qualities were fostered at all levels through a common commitment to Alliance values and high performance outcomes. Delivering six months ahead of schedule on a highly complex project during a construction boom was an exceptional outcome. This effort was attributed to excellence in project management and a robust approach to construction planning.

MANAGEMENT INNOVATIONS

Along with the technical innovations, the INB HUB Alliance adopted and implemented management innovations that ensured the success of the project. Adoption of sub-alliances was instrumental in aligning key subcontractors with a shared vision for project outcomes and was particularly relevant with piling subcontractors (given the high demand for these skills at the time). The sub-alliance agreement gave increased incentive for these subcontractors to deliver under or within the time and budget agreements.

Key leadership initiatives created an effective management framework for project delivery. These included training initiatives to encourage performance, embedding stakeholder representatives in the team and well run occupational health and safety programs, all contributing to the shared vision and strong performance. These innovations which demonstrate effective management are detailed below.

Effective Management through Training

The Alliance placed a high priority on workplace training to achieve a culture of exceptional performance, with a shared vision of success across multi-disciplinary teams. Recognising that well-trained people achieve outstanding goals, the management team developed a program to achieve the best outcomes for both the project, and the team as individuals. The effectiveness of training and resulting one team culture meant the team developed a shared sense of responsibility.

Effective Management for Innovation

The benefits of innovation can be seen in many of the INB's construction solutions. This was supported by strong leadership and effective management which empowered the whole team.

Innovations Generate a Legacy for Industry

In addition to the innovative solutions developed through the use of horizontal propping and suspended floor slabs within the KGS Car Park, the Alliance Management Team explored many other design and construction ideas which form a platform for the future in the industry. Some of these have been outlined previously, and are touched on briefly here since they illustrate leadership driven innovation:

- the plan to re-use the existing redundant rail bridge at Countess Street to help avoid major traffic disruptions and save costs
- the stimulation to progress smaller projects within the area. The team was able to deliver a number of these, including part of BCC's redevelopment of KGS, the Cycle Centre and Caxton-Roma Pedestrian Link
- innovative containment measures to prevent fires from spreading between the busway and the neighbouring infrastructure, and
- effective smoke duct and smoke management approaches.

Embedding of Stakeholder Personnel in the Project's Management Team

A number of Alliance stakeholder management strategies facilitated the success of the project, including the strategic placement of personnel from key stakeholders within the project team. These roles played a critical communication link and facilitated shared understanding. They included TransLink representative, BCC Project Liaison Manager, BCC Traffic Coordination Officer and QR Project Liaison Officer.

KEY RESULT AREAS (KRAs) AND PROJECT OUTCOMES

Contemporary construction in a CBD environment is about delivering a holistic urban outcome which combines excellence in design, construction, community and stakeholder relations and quality. The INB HUB Alliance team consistently demonstrated speedy, innovative responses needed for success. Planned project activities and ideas were continually challenged and the goals for milestones were repeatedly made harder**.**

To measure KRAs, the project developed a points-based ratings scheme that allowed a negative or positive rating, spanning a spectrum from minus 100 to plus 100. The seven KRAs were: Time; Cost; Community; Stakeholders; Big Q Quality; Environment and Sustainability; and Culture and People. These KRAs were clearly important to the project owner, QT, and equally important to the Alliance. The KRAs were measured objectively, as outlined below. Although safety was not a specific KRA, the project team placed the highest priority on managing this important factor.

The INB team was determined to achieve exceptional results beyond all expectations. To do this, the team identified and agreed extremely challenging targets for key elements of the project. Innovation, collaboration and determination lead to the Alliance achieving exceptional results against KRA targets as shown in Figure 7.

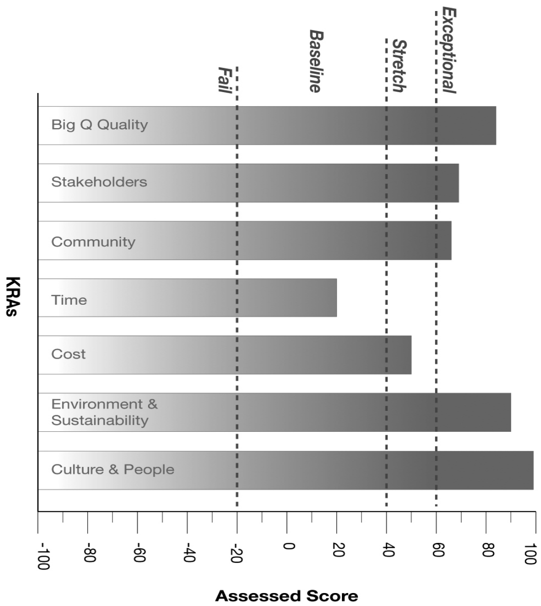

Figure 7: Results for the INB HUB Alliance (Queensland Transport, Leighton Contractors, Maunsell (now AECOM), Coffey, Bligh Voller Nield and EDAW (now EDAW AECOM)

Every Alliance team member contributed to reaching the highest standards by collaborating on innovative solutions to set new benchmarks for success. Outstanding leadership, team commitment, and expert management made these results possible. This was reflected in specific achievements as indicated above. For example the Alliance:

- delivered the INB under budget and six months early
- lived and breathed a “Safety above all else” culture which drove outstanding outcomes, including zero Class One incidents in close to two million man hours

- was unique at the time in appointing a peak performance manager, establishing a Peak Performance Plan and tracking People and Culture as a KRA
- adopted extensive sustainability initiatives including the early use of Green Power for all project offices
- conserved a number of significant cultural heritage discoveries and delivered additional city legacies, and
- used innovation to adapt existing structures such as a Countess Street rail bridge and the KGS car park.

The exceptional results achieved on the INB have been recognised by major industry awards including the Alliancing Association of Australia (High Commendation – Alliance Team of Excellence Award); Civil Contractors Federation Earth Award (State Award for Project Greater than $75million); Public Relations Institute of Australia Award (Winner – Community Relations Award); Public Relations Institute of Australia (Commendation - Golden Target Awards for Excellence (National) - Community Relations Category) during 2008.

CONCLUSIONS

The initiatives created by strong leadership, and delivered on-site show that the methods followed by the Alliance were highly effective. The INB is the result of demonstrated leadership with a shared vision, coupled with good management to achieve excellent implementation.
Busway patrons, commuters and all who experience the Brisbane CBD are the winners.

In design and construction innovation, and in benefits delivered to the public, the INB is indeed a proven platform for the future.

The relatively modest budget of $333 million belied the myriad complexities and high profile nature of the project. Meeting the budget was a major challenge – a previous attempt by others to deliver the project had failed, with budget a contributing factor. The Alliance team not only completed the INB under budget, but also delivered outstanding outcomes across the Key Result Areas (KRAs) of Schedule; Cost; People and Culture; Quality; Stakeholder and Community Relations; and Environment and Sustainability. Highly effective safety management was also achieved. The challenge was met by the INB HUB Alliance team of Queensland Transport, Leighton Contractors, Maunsell (now AECOM), Coffey, Bligh Voller Nield and EDAW (now EDAW AECOM) – and was supported by Brisbane City Council.

The complexity of constructing the INB can be summed up by the following: no single 50m section was the same. Similar can be said for the myriad of design refinements, logistical requirements, impacted stakeholders, safety challenges and time constraints: every challenge was different. The true success of this project is that it seamlessly blends with the heart of Brisbane, with minimal acknowledgement of its complex and challenging past. The INB project truly reflects the Alliance teams' keenness to deliver a significant project using management and technical innovations.

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